BC Nephrology DAYS 2005

The "Downside" of Hemodialysis' Hemodynamic Challenges

Dr. Beverly Jung, MD, FRCP(C)
Nephrologist, SPH

Common Intradialytic Complications

- **HYPOTENSION**
- Arrhythmia
- Hypoxemia
- Muscle cramps
- Anaphylactic reactions
- Dialysis Disequilibrium
  - Nausea, vomiting
  - Headache
- Hypertension

Overview

- Definition and prevalence
- Pathophysiology
- Treatment strategies
- Interactive case reviews

Definition

- Many different definitions in the literature
  - SBP <100 mm Hg or BP drop >20 mm Hg with concomitant symptoms
    - Dizziness, blurred vision, cramps, fatigue
  - Rapid changes in BP
    - Fall of >40 mm Hg systolic or >20 mm Hg diastolic within 15 min. period regardless of symptoms or whether requires nursing interventions

Prevalence

- May complicate 10-30% of all HD treatments
- Affects 20-50% of HD pts.
- Frequency has not decreased despite improved technology such as ultrafiltration controllers
- High risk patient population

Consequences

- Clinical Sequelae
  - Neurologic - seizures, stroke
  - Cardiac - angina, MI, arrhythmias
  - Mesenteric ischemia
  - Vascular access closure
  - Decreased adequacy of dialysis treatment
  - Prevents achievement of goal weight
- Increased morbidity and mortality related to patient population comorbidities

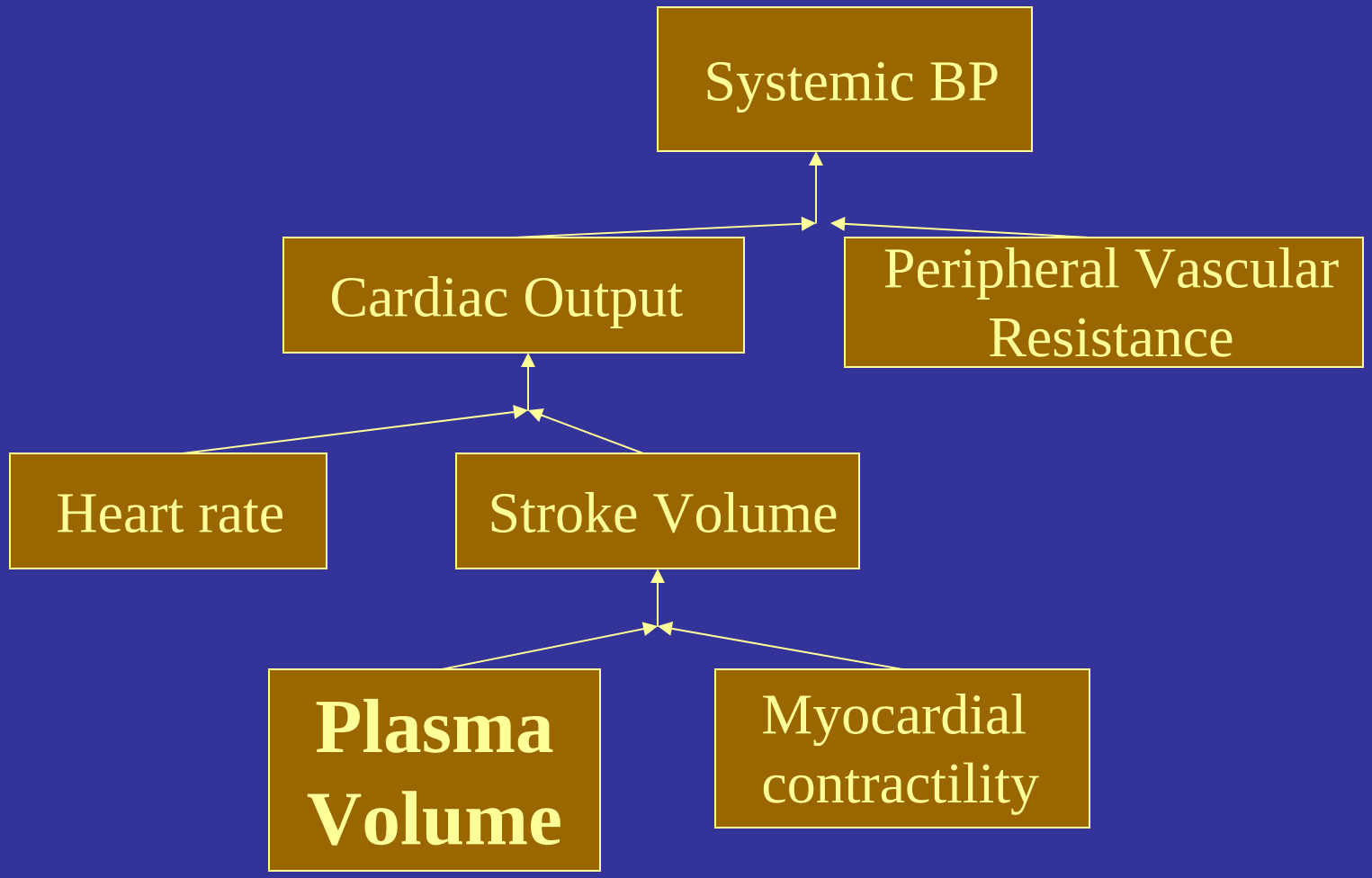
“Unphysiology” of Hemodialysis

- Major reason for side effects is severe fluctuations in various ions and water which may be detrimental to cells of the body
  - Intermittent short dialysis procedure
  - Vigor or efficiency of each individual dialysis
  - Patient non-compliance with fluid, protein, electrolytes

Multifactorial Causes

- Patient Related factors
  - Limited cardiac reserve – systolic and diastolic dysfunction
  - Arterial tone and venous capacitance
  - Autonomic dysfunction (neuropathy)
- Dialysis Related Factors
  - Ultrafiltration, amount and rate
  - Decline in plasma osmolality
  - Warm dialysate temperature
  - Dialysate electrolytes, sodium, calcium, magnesium
  - Dialysate buffer, acetate vs. bicarbonate
  - Membrane interactions
- Other
  - Antihypertensives and negative inotropes

Determinants of Systemic BP



Compensatory Mechanisms

- Plasma Refilling
- Venous Capacity
- Arteriolar Resistance
- Cardiac

Plasma Volume

- Approximately 3 L
- Entire plasma volume removed during typical dialysis session
- Blood volume drops by 5-20% because:
  - Plasma refilling from:
    - Intracellular and interstitial fluid compartments
    - Splanchnic and cutaneous circulation
  - UF leads to:
    - Increase in plasma oncotic pressure
    - Drop in capillary hydrostatic pressure
    - Both mobilize fluid from extravascular space
- Plasma volume falls depending on:
  - relative UF rate
  - plasma refilling rate

Plasma Refilling Rate

- Direct relationship with size of interstitial compartment
- Still very variable between patients of similar interstitial compartment size
- Higher risk of hypotension if low proteins or high ureas (oncotic & osmotic forces)
- Hypotensive episodes are common when extra/intravascular fluid shift occurs at a rate of <4 ml/mm Hg/min.
- Also dependent on sodium

Poor Plasma Refilling

- Inadequate arteriolar and venous vasoconstriction leading to venous pooling
  - Autonomic neuropathy
    - Ineffective sympathetic nervous system
  - Factors leading to vasodilatation
    - Need to dissipate heat
    - Medications
    - Buffers
    - Ischemia creating adenosine
  - Eating on dialysis
    - Increases splanchnic blood flow
    - Increases production of gastric fluids

Compensatory Mechanisms

- Plasma Refilling
- Venous Capacity
- Arteriolar Resistance
- Cardiac

Venous Compliance

- Crucial for adjustments to changes in intravascular volume
- Provides capacitance of circulation
  - Venous systems holds 60-80% of blood volume
- Reduced in hypertensive HD patients
  - Cannot be normalized with medications
  - Suggests structural abnormalities
    - Increased media of venous wall

Arterial Compliance

- Arterial stiffness and loss of arterial compliance
  - Arteriosclerosis
    - Gross intimal fibrosis and medial calcification
    - Lipid deposits are infrequent
    - Caused by uremia
- Correlates with development of LVH

Autonomic Neuropathy

- Occurs in >50% of dialysis patients
- Afferent limb defect of baroreceptor function
  - Situated at carotid sinus
  - Minimized reflex increase in catecholamine release
- Downregulation of alpha-adrenergic receptors
  - Diminished response to endogenous catecholamines
- Paradoxical reflex- Bezold-Jarisch reflex
  - Decreased sympathetic and parasympathetic activity
  - Cardioinhibitory- sinus bradycardia and lower BP

Compensatory Mechanisms

- Plasma Refilling
- Venous Capacity
- Arteriolar Resistance
- Cardiac

Cardiac Function

- Diastolic Dysfunction or LVH
  - Inability for ventricle to relax during diastole resulting in reduced stroke volume
- Systolic Dysfunction
  - Diminished cardiac reserve in situation of hemodynamic challenge

LV Diastolic Volume

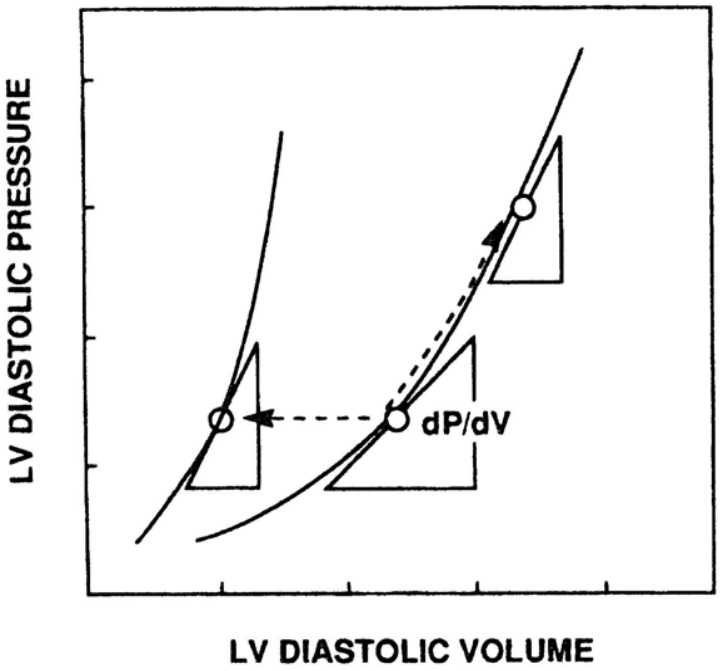
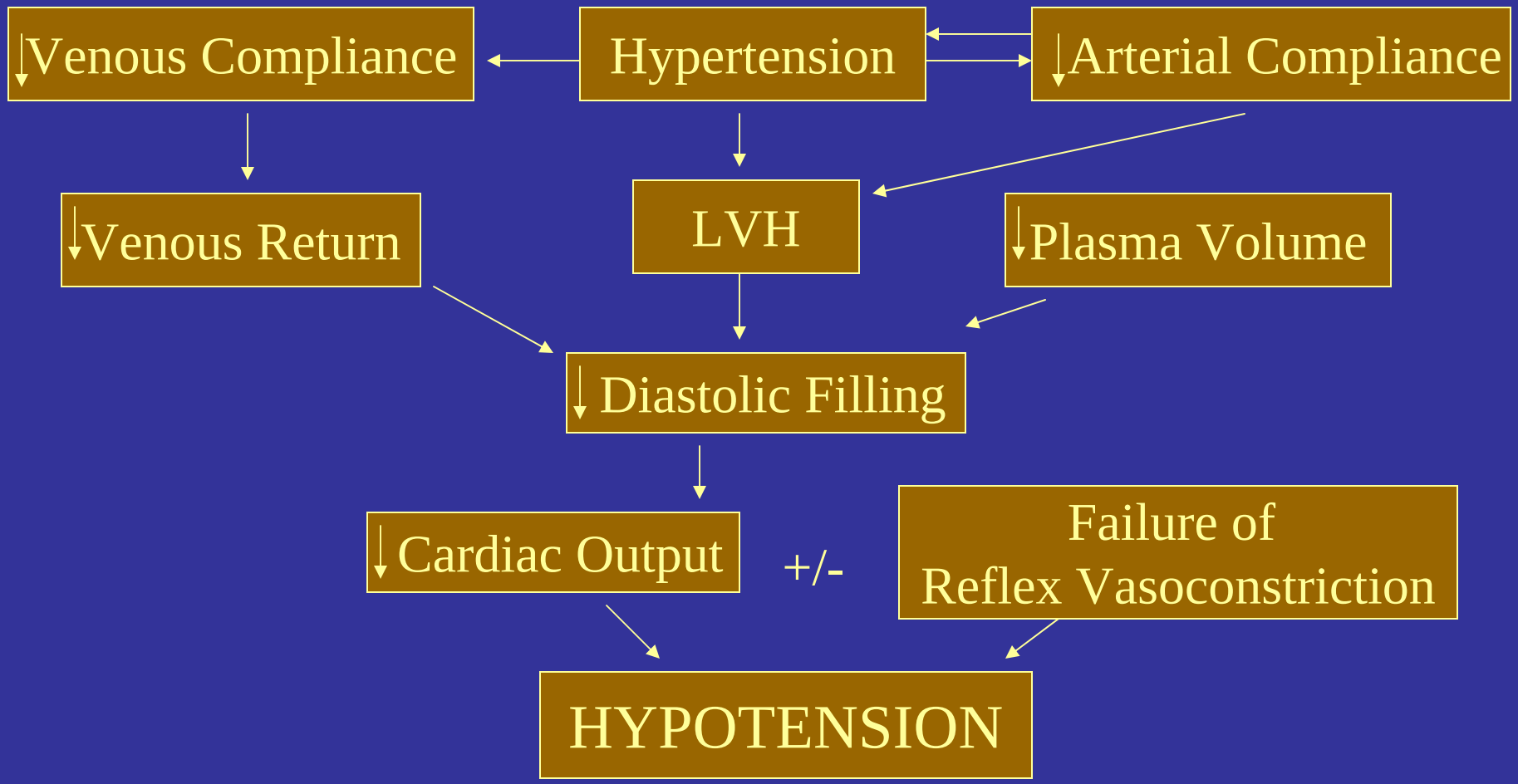


Fig. 1. Compliance characteristics of the left ventricle during diastolic filling. In end-stage renal disease a leftward shift of the pressure–volume relationship is common, such that myocardial compliance is decreased. Reproduced from [8], with permission.

Raine, AEG. NDT 1996; 11 (Suppl 2): 6-10.

Physiologic Factors in Intradialytic Hypotension



BC Nephrology DAYS 2005

Treatment Strategies

Dry Weight

- Requires frequent assessment
  - If patients are eating well, they can develop more tissue mass or vice versa
  - Clinical examination lacks sensitivity and specificity
- Encourage patient compliance with fluid and sodium intake
  - High dietary sodium increases thirst
  - Adjustment of dialysate sodium to prevent thirst and thus high interdialytic weight gain
  - Need to balance with attempts to prevent intradialytic hypotension

Methods to Assess Volume Status

- IVC diameter
- Bioimpedance

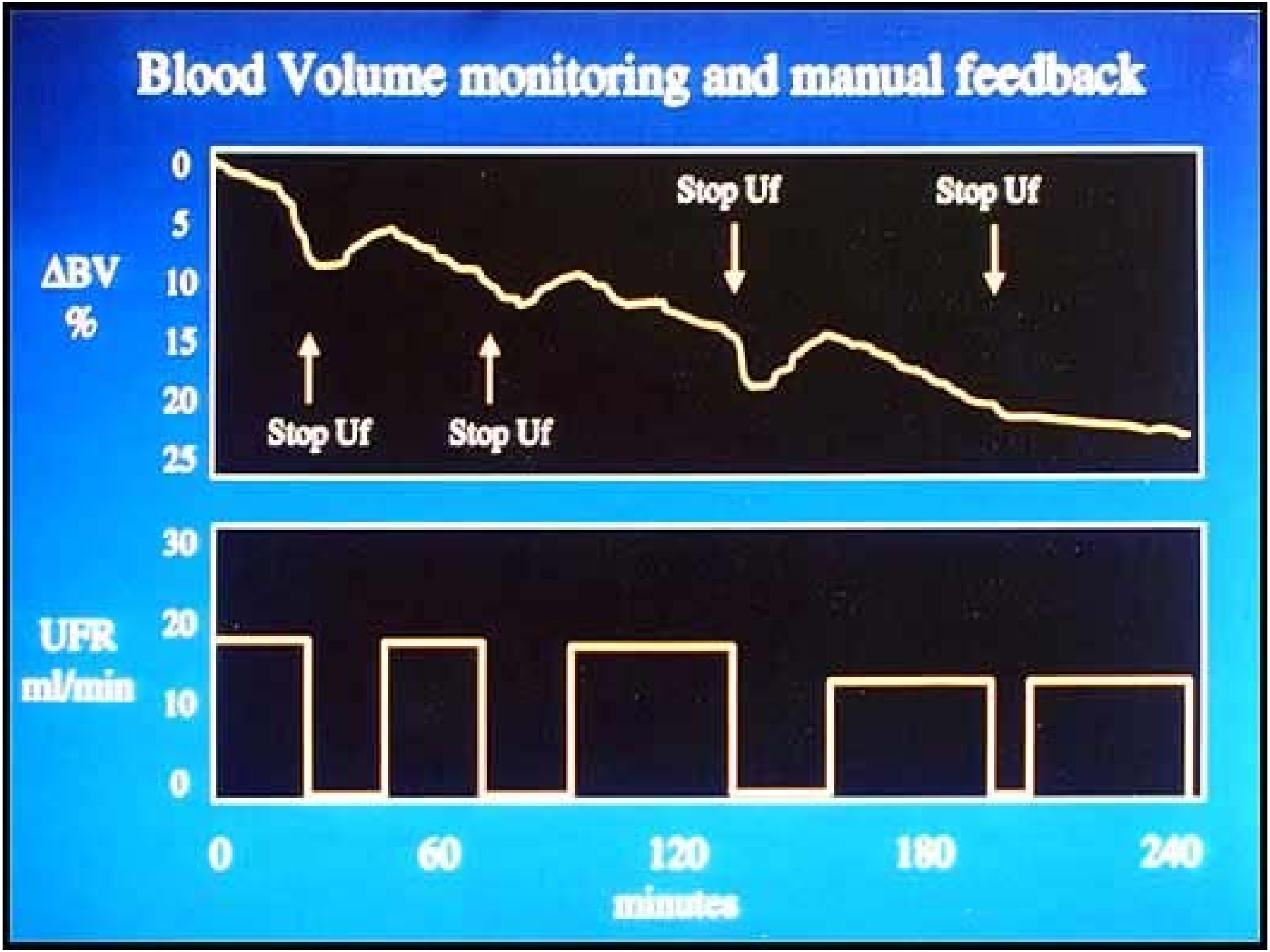
} *Not practical to use on daily basis*

- Continuous Blood Volume Monitoring
  - Small decrease in BV could suggest fluid overload
    - Dry weight could be adjusted lower
  - Achieve patient-specific ideal curve of blood volume decline
    - Can reduce hypotensive episodes by 30%

Ultrafiltration

- Isolated UF
  - Reduces efficient dialysis time
  - Can be considered if total time on dialysis is increased
  - May not be better than just increasing total time
- UF modeling
  - Allows for plasma refilling when at risk for hypotension
  - Can profile in concert with sodium
    - Hemocontrol Biofeedback System (Hospal, Italy)
      - Automatically decreases UF rates or increase dialysate conductivity if Blood volume falls below predefined level

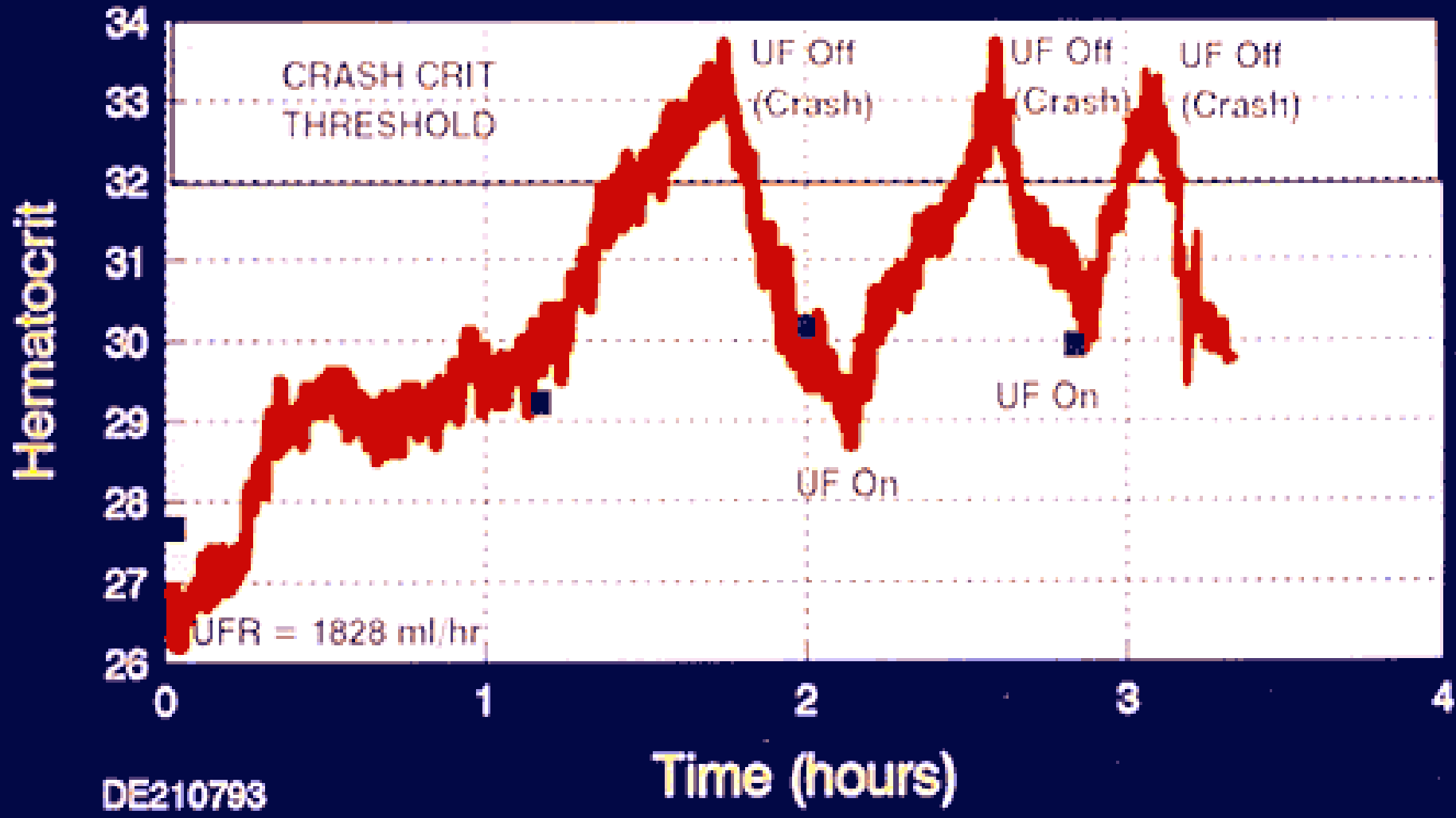
Blood Volume monitoring and manual feedback



Blood Volume Monitoring "Crit Monitor"

- Stable hemoglobin 110-120
  - Anemia, decreased oxygen delivery, ischemia
  - Transfusions reduced hypotension by 50% when Hb <60
- Crash Crit
  - Hematocrit at which UF rate exceeds plasma refilling rate causing hypotension
  - Real-time surveillance of blood volume changes

CRASH CRIT Observed



Individualize Treatment

- $RBV_{critical}$
- Symptomatic hypotension when blood volume below 50 ml/kg
- Discover individual limit and develop algorithm to predict point of risk

Barth C et al. NDT 2003;18:1353-1360.

Characteristics of Hypotension-Prone HD Patients

Table 1. Concomitant diseases in the study population

	Prevalence (% of all patients)	Prevalence (% of female patients)	Prevalence (% of male patients)
Hypertension	64.4	75.0	47.8
Diabetes mellitus	44.1	55.6	26.1
Congestive heart failure	28.8	25.0	34.8
Coronary heart disease	27.1	27.8	26.1
Peripheral arterial occlusive disease	25.4	30.6	17.4
Autonomous neuropathy	18.6	22.2	13.0
Cardiac arrhythmia	15.3	13.9	17.4
Chronic hypotension	5.1	0.0	13.0

Barth C et al. NDT 2003;18:1353-1360.

Characteristics of Hypotension-Prone HD Patients

Table 2. Patient characteristics according to gender and diabetes mellitus

	All patients	Female patients	Male patients	*P* (gender)	Patients with DM	Patients without DM	*P* (DM)
Distribution (%)	100	62	38		57	43	
Age (years)	66 ± 11	65 ± 11	68 ± 11	0.34	64 ± 8	68 ± 12	0.11
Weight (kg)	73 ± 16	71 ± 15	78 ± 15	0.11	77 ± 3	71 ± 3	0.05
BMI (kg/m^2)	26.6 ± 4.9	26.8 ± 5.2	26.2 ± 4.6	0.70	28.1 ± 3.9	25.4 ± 5.3	0.04
UFV (% of weight)	3.7 ± 1.4	3.6 ± 1.3	3.9 ± 1.5	0.47	3.8 ± 1.3	3.7 ± 1.5	0.15
sBP (mmHg)	147 ± 25	152 ± 24	136 ± 24	0.01	155 ± 28	140 ± 22	0.03
dBP (mmHg)	82 ± 18	84 ± 19	78 ± 17	0.23	85 ± 19	78 ± 17	0.12
RBV_{crit} (%)	88.7 ± 6.2	88.8 ± 5.9	88.6 ± 6.9	0.77	88.7 ± 6.2	88.8 ± 6.4	0.50
IME per HD session	1.1 ± 0.7	1.1 ± 0.8	1.0 ± 0.7	0.50	1.2 ± 0.8	0.9 ± 0.7	0.06

sBP/dBP, systolic/diastolic blood pressure at start of treatment; UFV, ultrafiltration volume (relative to dry weight). All values are given as mean ± SD.

Barth C et al. NDT 2003;18:1353-1360.

Intradialytic Morbid Events

Table 3. Summary of 760 reported symptoms during 537 intradialytic morbid events

Symptom	Frequency	Frequency (%)
Hypotension	508	66.8
Cramps	99	13.0
Dizziness	36	4.7
Nausea	23	3.0
Headache	15	2.0
Vomiting	13	1.7
Others	66	8.7
Total	760	100.0

Table 4. HD sessions with no, one and multiple intradialytic morbid events (IME)

No. of HD sessions	No. of IME per session	Frequency (%) of all sessions
265	0	45.3
183	1	31.3
79	2	13.5
41	3	7.0
12	4	2.1
5	5	0.9

Barth C et al. NDT 2003;18:1353-1360.

Intradialytic Morbid Events

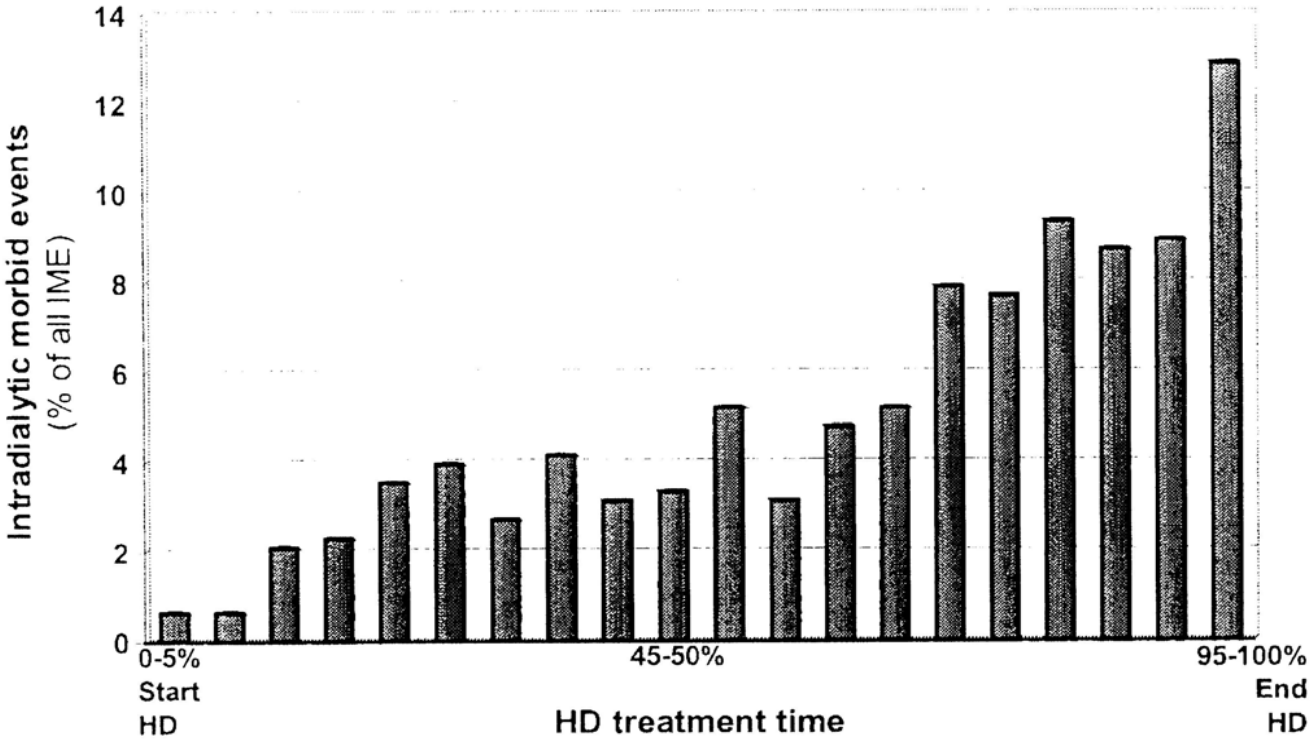
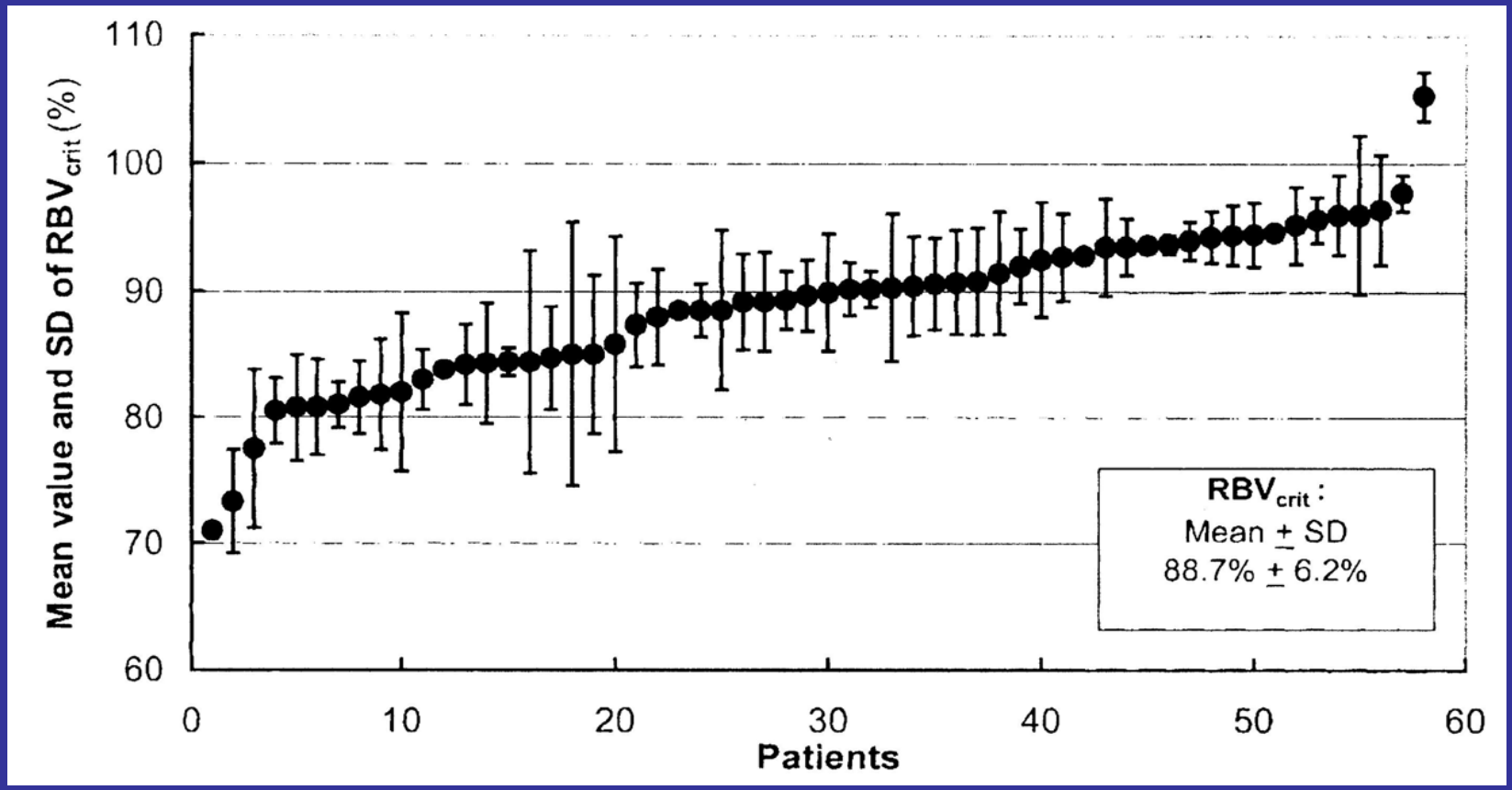


Fig. 1. Distribution of intradialytic morbid events (IME) over the HD session. Each bar represents the percentage of IME in the indicated 5% of the delivered treatment time.

Barth C et al. NDT 2003;18:1353-1360.

Critical Relative Blood Volume $RBV_{critical}$



Barth C et al. NDT 2003;18:1353-1360.

Critical Relative Blood Volume $RBV_{critical}$

Table 5. Cumulative patient distribution of the individual RBV_{crit}

RBV_{crit}	No. of patients	No. of patients (%)
≤ 80	3	5.0
≤ 85	19	31.7
≤ 90	30	50.0
≤ 95	51	85.0
≤ 100	57[a]	95.0[a]

[a]One patient with $RBV_{crit} > 100\%$, and two patients without RBV_{crit} during the observation period.

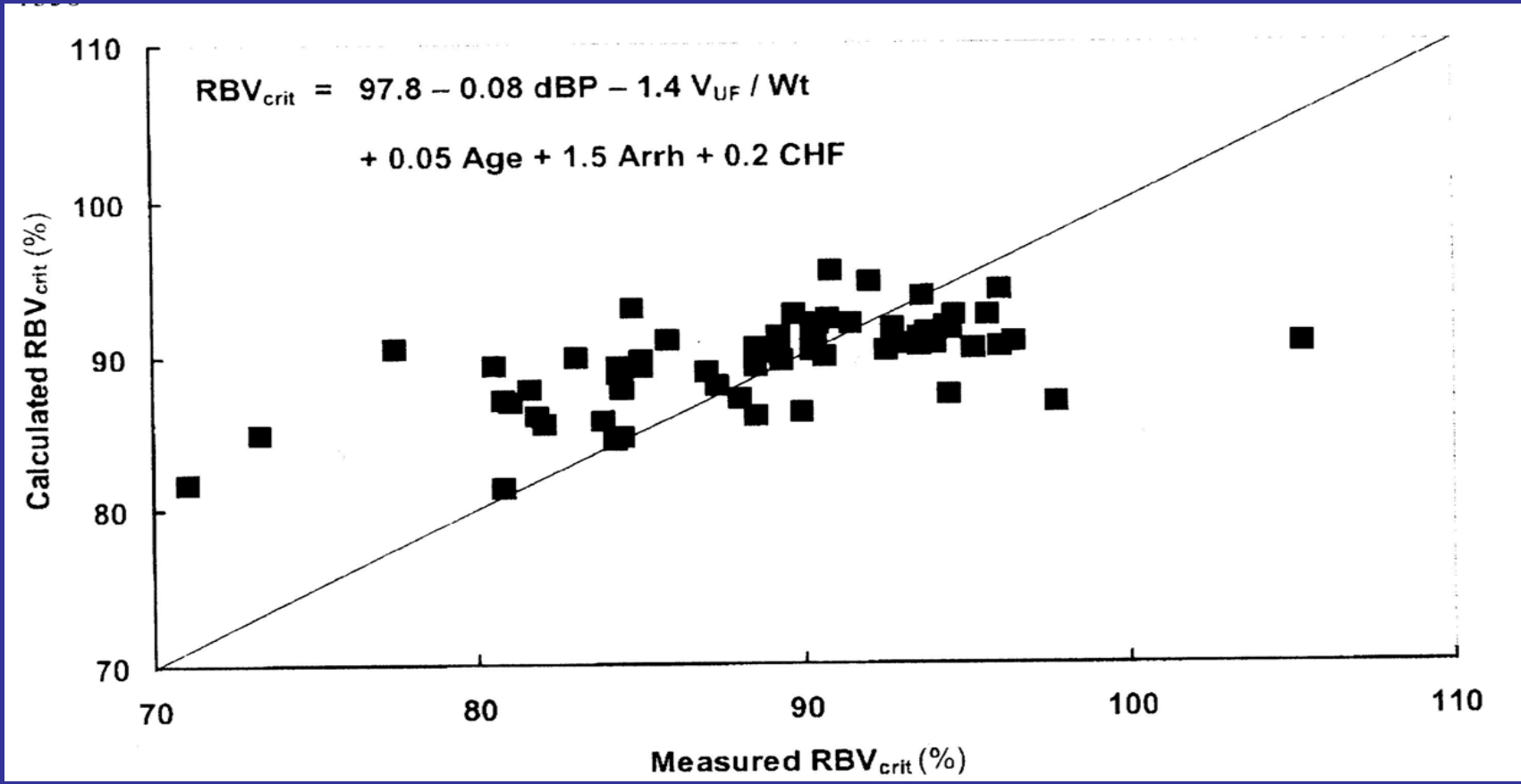
Table 6. Cumulative intra-individual variability of RBV_{crit}

SD	No. of patients	Sum (%)
$\leq \pm 1\%$	4	6.7
$\leq \pm 2\%$	12	20.0
$\leq \pm 3\%$	24	40.0
$\leq \pm 4\%$	35	58.3
$\leq \pm 5\%$	46	76.6
$\leq \pm 6\%$	47	78.3
All patients	60	100.0

Mean $\pm$ SD: $3.6 \pm 2.1\%$.

Barth C et al. NDT 2003;18:1353-1360.

Algorithm



Barth C et al. NDT 2003;18:1353-1360.

Sodium

- Low dialysate Na assoc. with hypotension
- Low dialysate Na reduces serum Na
  - Drives ECF water into cells
  - Reduction in plasma volume
- Higher serum sodium may have direct vasoconstrictor effect (vasopressin effect)
  - Trial of Na ramping so that by end of HD treatment, patient has not gained sodium
  - Individualize dialysate Na (predialysis sodium)
    - Osmolality set point

Individualized Dialysate Sodium Prescription

- Reduction in interdialytic weight gain
  - Reduction in UF
- Reduction in interdialytic thirst
- Improvement in predialysis BP in hypertensive patients
- Adjustment in sodium prescription based on predialysis values may be used safely
  - Limitation of study – patients prone to hypotension may not tolerate

De Paula FM et al. KI 2004; 66: 1232-1238.

UF and Sodium Profiling

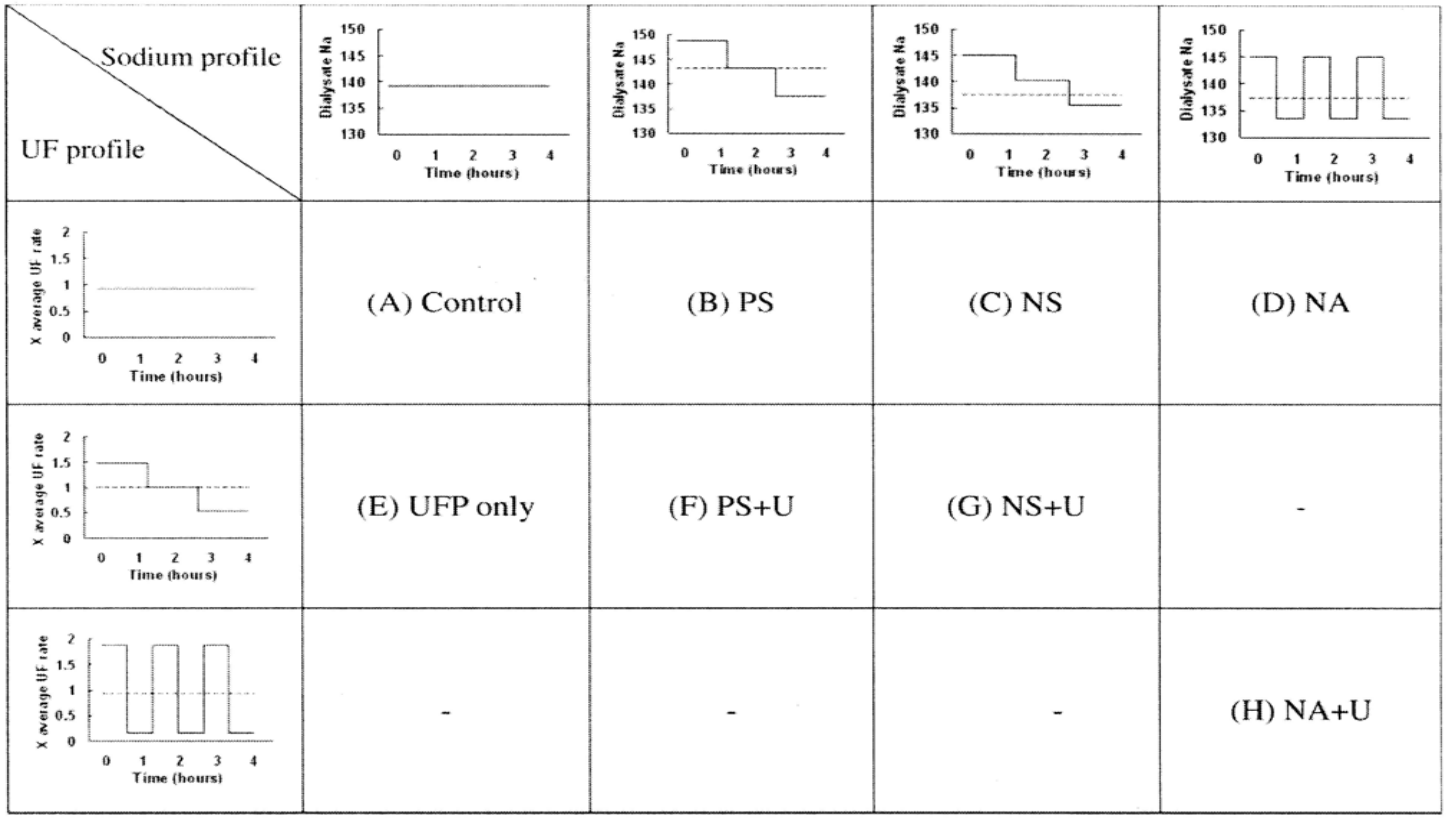
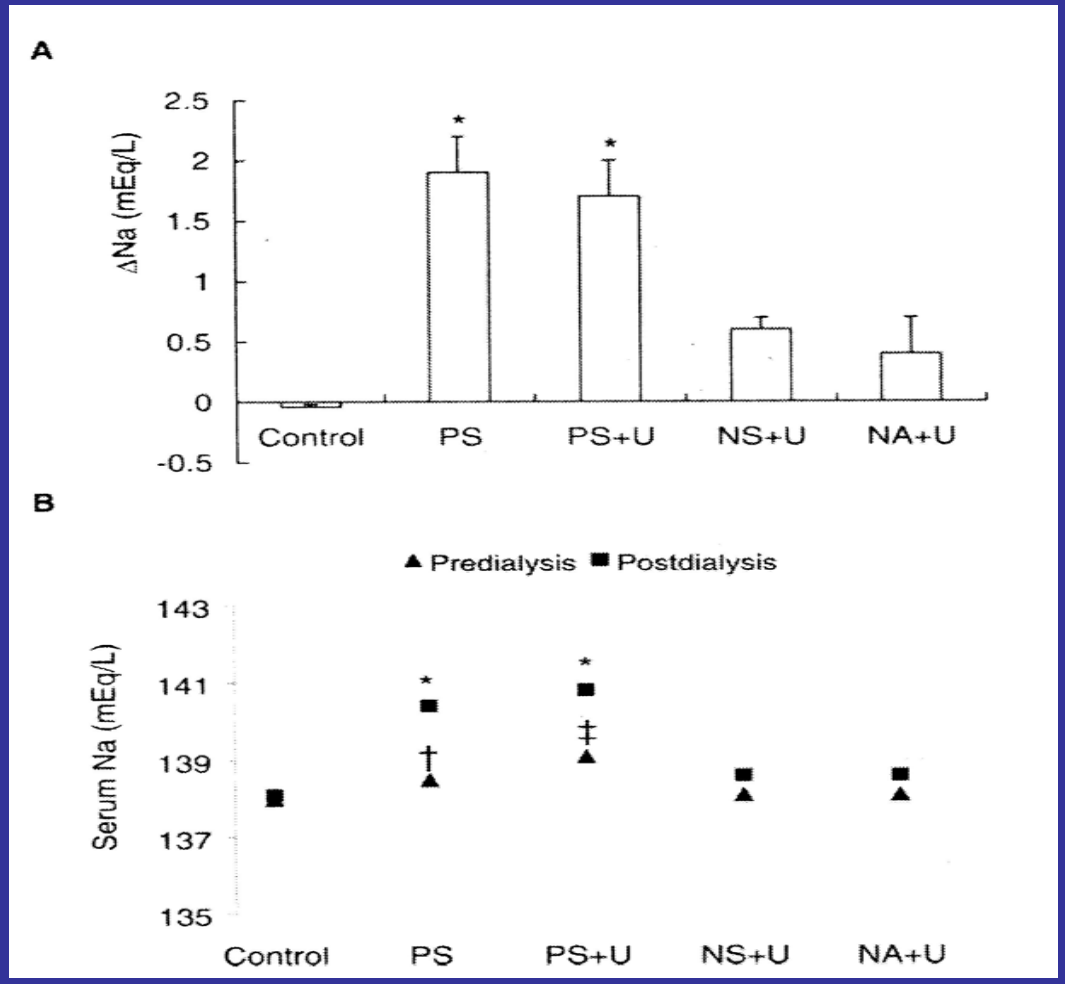


Figure 1. Treatment protocols. (A) Conventional hemodialysis (HD; control; dialysate sodium 138 mEq/L). (B) Sodium balance–positive step-down sodium profiling HD (PS; time-averaged mean of dialysate sodium 143 mEq/L). (C) Sodium balance–neutral step-down sodium profiling HD (NS; 138 mEq/L). (D) Sodium balance–neutral alternating type sodium profiling HD (NA; 138 mEq/L). (E) Conventional HD + step-down ultrafiltration profile (UFP; UFP only; 138 mEq/L). (F) PS + step-down UFP (PS+U; 143 mEq/L). (G) NS + step-down UFP (NS+U; 138 mEq/L). (H) NA + alternating type UFP (NA + U; 138 mEq/L). Dotted line, time-averaged mean of dialysate sodium or UF rate during the session.

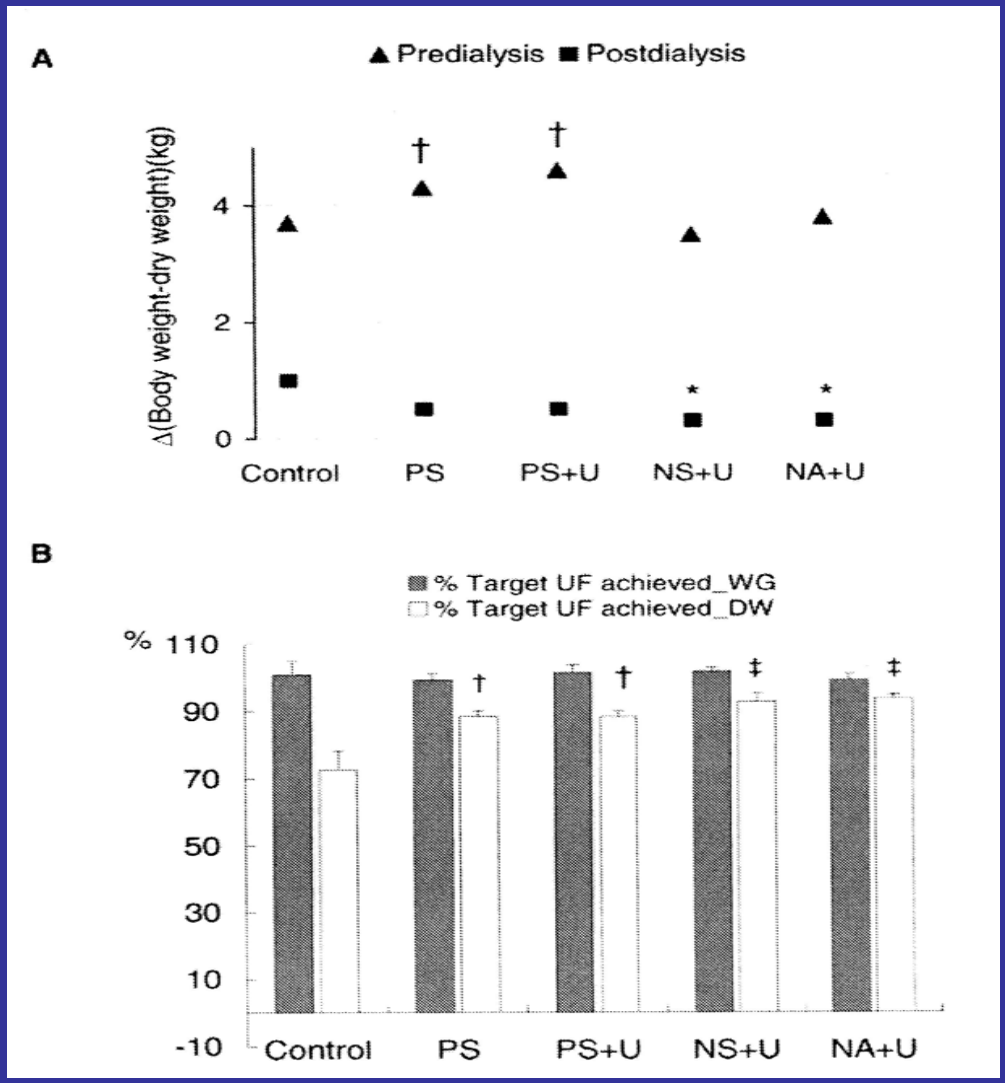
Song, JH et al. JASN 2005; 16: 237-246.

UF and Sodium Profiling



Song, JH et al. JASN 2005; 16: 237-246.

UF and Sodium Profiling



Song, JH et al. JASN 2005; 16: 237-246.

Cool Dialysate

- Subnormal core temperature in 20% of dialysis population
- 34-35 C dialysate
  - Increases peripheral vasoconstriction
  - Increase cardiac inotropy
  - Increase in catecholamines
  - Risk of increasing myocardial oxygen demand in patients with CAD and precipitate angina
- Cool HD room
- Post dialysis hypotension is not more common
- “Isothermic”dialysis

Thermoneutral vs. Isothermic

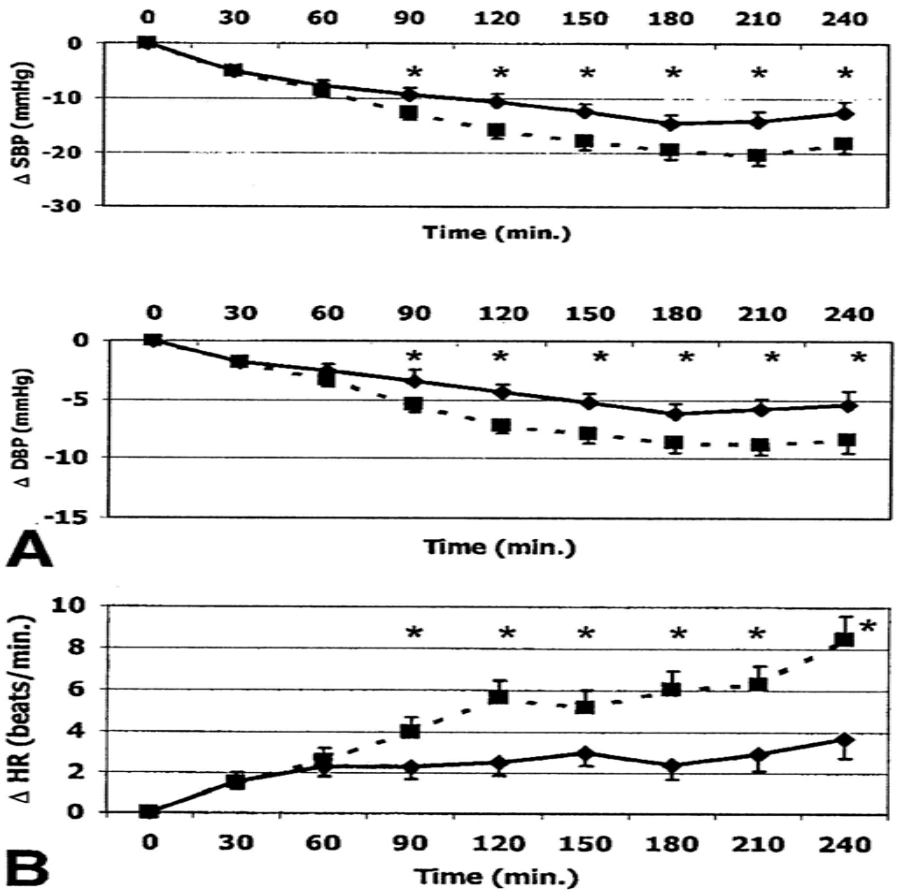


Fig 6. Changes over time in (A) systolic (ΔSBP) and diastolic blood pressure (ΔDBP) and (B) heart rate (ΔHR) during the two treatments. Values given as mean ± SEM. *$P < 0.05$. (- ■ -) Thermoneutral HD; (-◆-) isothermic HD.

Maggiore Q et al. AJKD 2002;40:280-290.

Midodrine

- Pro-drug of alpha-1-adrenergic receptor agonist, desglymidodrine
- Induces constriction of both arterial and venous capacitance vessels
- Peak levels achieved in 1 h; $T^{1}/_{2}$=3 h
- Few side effects
- Safe in patients with CAD

Systematic Review

- 9 studies
- Exclusion criteria
  - Patients on antihypertensive agents
  - Active Medical Conditions
  - Vascular Access Dysfunction
  - Dialysis with a catheter
  - Pericardial Effusions
  - Impaired LV documented on echo
  - Diabetes

Prakash S et al. NDT 2004; 19: 2553-2558.

Systematic Review

- Dosing ranged from 2.5 –10 mg given 15-30 min. prior to onset of dialysis treatment
- Six out of 10 reported improved symptoms
- Conclusion
  - Midodrine can blunt the drop in BP during HD
  - Limitation was poor quality of studies
    - Only 2 were crossover in design; no RCTs
    - Small groups of patients
    - Does not answer whether there is any added advantage over cool dialysate
      - No discernible difference between the two strategies

Prakash S et al. NDT 2004; 19: 2553-2558.

Approach to Midodrine Therapy

- Initiate therapy 30 minutes before HD at dose of 2.5 – 5mg and titrate upwards
  - Maximum daily dose of 30 mg
- May give a second dose if there is mid-dialysis or post dialysis hypotension
  - Give dose midway during HD treatment
- Avoid during active coronary ischemia

Sertraline

- Serotonin re-uptake inhibitor
- Preserves central sympathetic activity through inhibition of excessive serotonin in CNS
- Allows alpha-1-adrenergic receptor mediated venous and arteriolar constriction
  - Theoretical

Sertraline

- Would it improve BP in patients already receiving other treatments?
  - Cool dialysate, midodrine, sodium profiling
- 18 patients in crossover design
- Measured CO, CBV, PVR with US dilution
  - Not statistically different with or without sertraline 50 mg/day

Brewster UC et al. Nephrology 2003; 8: 296-301.

Caffeine

- Adenosine is an antagonist of norepinephrine
  - Release following hypotension which may cause ischemia
    - Breakdown from ATP
- Caffeine 250 mg (4 cups of coffee) given 2 hrs. into dialysis
  - Reduction in sudden hypotension
  - No difference in common gradual hypotension

Carnitine

- Co-factor to move fatty acids into mitochondria of cells
- Deficiency may cause asthenia, hypotension, cardiomyopathy
- Dose of 20 mg/kg IV at end of HD
- Hypotension reduced by 44% to 18%
- Not readily available and expensive
- Oral doses of 1 g for muscle cramps

Composition of Dialysate

- Low calcium baths
  - Lowers cardiac contractility
  - 2.5 vs. 3.5 baths
  - Risk of hypercalcemia with higher baths
  - No benefit in those with EF<40%
- High Mg baths
  - Causes vasodilation; used for treatment of eclampsia
- Mg 0.25 baths in combination with low Ca 1.25
  - Mg 0.75 preserved BP if using Ca 1.25 but not 1.75
- Bicarbonate baths
  - Dialysate bath of 32 vs. 26

Intravenous Fluids

- Normal Saline
- Albumin
  - 5% albumin no more effective than NS
  - More expensive
- Mannitol
- Hypertonic saline
  - 5 ml boluses, 3 doses 10 minutes apart
  - Potentially can cause hypernatremia
- Hypertonic glucose

Salty Broth

- Slower method of providing saline
- Requires absorption from gut
- Only should be offered if lines have been removed

Avoid Medications

- Long acting CCBs or ACEI vs. short-acting
- May hold meds on day of HD
- Trial and error
- Verapamil may be helpful for diastolic dysfunction
  - Relaxation of stiff left ventricle allowing for proper filling during diastole
  - Preserved stroke volume

Dialyzer membranes

- Biocompatible theoretically better for hemodynamic stability
- Long term benefits
  - Long term survival
  - Fewer infections
  - Fewer hospitalizations

Underlying Disease

- Dialysis related Amyloidosis
  - Hypotension during dialysis and interdialytic period
  - Postural Hypotension
  - Amyloid infiltration of blood vessels or sympathetic nerve endings
- Adrenal Insufficiency
- Pericardial Effusion

Exercise

- Improves quality of life by increasing stamina
- Increases Hgb, normalizes lipid patterns
- Increases cardiovascular stability

Blood Flow

- Increasing BFR increases dialysis of small solutes
- Extracellular fluid osmolality falls
- Shift of intravascular fluid to intracellular
- Reducing BFR will reduce efficiency of HD

Daily and Extended HD

- Perform HD over a longer duration
- Add extra HD days
- Extended HD can increase arterial baroreflex sensitivity and compliance
  - Normalizes BP, reduces LVH

Nocturnal HD

Table 1. Dialsyis dose, hemodynamics, baroreflex sensitivity for heart rate, and medication requirements before and after 2 months of nocturnal hemodialysis

Variables	Conventional hemodialysis	2 months of nocturnal hemodialysis	*P* value
Kt/V per session	1.2 ± 0.05	2.1 ± 0.1	0.008
Phosphate *mmol/L*	2.01 ± 0.3	1.29 ± 0.11	0.04
Systolic blood pressure *mm Hg*	143 ± 4	120 ± 6	0.001
Diastolic blood pressure *mm Hg*	86 ± 5	70 ± 5	0.02
Pulse pressure *mm Hg*	56 ± 3	49 ± 2	0.05
Heart rate min^{-1}	76 ± 7	77 ± 1	0.93
Stroke volume *mL*	55 ± 7	66 ± 9	0.07
Weight *kg*	64.1 ± 11.9	64.2 ± 11.7	0.70
Stroke volume/pulse pressure *mL/mm Hg*	0.98 ± 0.13	1.43 ± 0.2	0.019
Baroflex sensitivity *msec/mm Hg*	4.76 ± 1.1	6.91 ± 1.1	0.04
Medications	2.9	0.1	<0.001
Angiotensin-converting enzyme inhibitors *number*	5	0	
Angiotensin receptor blocker number	1	0	
β blocker *number*	3	1	
α blocker *number*	2	0	
Calcium channel blocker *number*	6	0	
Other vasodilators *number*	1	0	

N = 10. Values are presented as mean ± SEM or number, as indicated.

Chan CT et al. KI 2005;68:338-344.

Intradialytic Hypotension in ICU Patients with ARF

- CRRT (Prisma)
- SLEDD, SCUF
- Can use similar treatment strategies when performing intermittent HD
  - Sodium and UF profiling
  - Give Albumin to increase plasma oncotic pressure to help with vascular refilling
  - Cool dialysate temperature
  - IV vasoconstrictors, inotropes
  - Consider dialysate calcium, magnesium

BC Nephrology DAYS 2005

Case Reviews

S.V.

- 38 F
- Long CKD history
  - ESRD from HSP/IgAN 1976
  - 3 failed transplants, last Apr 2002
    - Restarted on HD in Jan 2003
- Precipitous BP drop in first 1-2 hrs of HD
  - Similar complication during prior HD history
  - Associated with headache and tachycardia
  - Receives Cafergot and Midodrine

Patient Data

- GW 42.2 kg
  - Average wt. gain 1.5-2 kg which is 3.5-4.7% of GW
- Dialysis – L upper arm AV graft
  - F70, BPS 300, Dialysate flow 750, dialysate temp 35.5 C
  - Na 138-132, K 1.0, Ca 1.25, Mg .3
- Predialysis Bloodwork
  - Hb 122, Na 136, K 5.5, HCO_3 31, albumin 40
- Medications
  - Usual CKD meds – EPO, Ca, IV iron
  - Not on antihypertensives
- Echo in November 2003
  - Normal global LV and RV function
  - LVMI normal (no LVH)

Typical Dialysis

Time	0740	0900	1000	1040
Fluid Removal (L)	0	0.94 (2.2%)	1.64 (3.9%)	1.86
Blood Volume Changes (%)	0	-7.0	-11.8	-
BP (mm Hg)	163/78	145/94	100/70	96/65
HR (per min.)	106	85	-	91

Time	0730	0850	0940	1030
Fluid Removal (L)	0	.81 (1.9%)	1.37 (3.2%)	2.0
Blood Volume Changes (%)	0	-5.7	-9.5	-11.7
BP (mm Hg)	116/67	126/80	118/76	135/80
HR (per min.)	112	93	89	92

Write the Dialysis Orders

- Dialysis time - increase to 4 hrs
- Filter, BPS, dialysate flow – no effect
- Dialysis solution
  - Na ramped already
  - Ca 1.5, Mg 0.75, lower HCO_3 bath
  - Temp – could decrease lower at time of risk
- NPO
- Adjust GW
- Medications – Midodrine at 90 min – 2 hrs

T.S.

- 79 M, DM2
- Cardio- & cerebro-vascular history
  - 1994 CVA
  - 1997 Complete heart block, pacemaker
  - 2000 CABG
  - Dyslipidemia, HTN
- Precipitous drop in first 1-2 hrs of HD and hypotensive at end of HD
  - Receiving Midodrine 5 mg pre-HD and at 2 hrs

Patient Data

- GW 82.3 kg
  - Average wt. gain 2.5-3 kg which is 3.0-3.6% of GW
- Dialysis- LIJ Permacath
  - F160, BPS 270, Dialysate flow 500, dialysate temp 36 C
  - Na 150-140, K 2.0, Ca 1.25, Mg .3
- Predialysis Bloodwork
  - Hb 112, Na 141, K 4.1, HCO_3 23, albumin 34
- Medications
  - Ramipril, Metoprolol – held prior to HD
  - Insulin, Plavix, Lipitor, Gabapentin, Darbepoetin, Tums
- Echo
  - Increased LV wall thickness to upper range of normal
  - Normal LV and RV systolic function

Typical Dialysis

Time	1220	1400	1500	1550	1620
Fluid Removal (L)	0	.91 (1.1%)	1.62 (2.0%)	2.16 (2.6%)	2.52 (3.1%)
Blood Volume Changes (%)	0	-3.1	-4.3	-6.6	-
BP (mm Hg)	157/57	96/59	175/75	168/66	110/44
HR (per min.)	72	83	80	81	70

Write the Dialysis Orders

- Dialysis time – could increase to 4.5-5 hrs
- Dialysis solution
  - Na ramped already
  - Adjust lower to avoid excessive Na gain which could be contributing to interdialytic fluid gain
  - Ca 1.5, Mg 0.75
  - Temp – could decrease lower at time of risk
- NPO
- Medications
  - Midodrine increased to 10 mg pre-HD
  - Give Midodrine 60 min. before end
  - Try Verapamil as antihypertensive

Y.C.

- 74 F DM2
- Schizophrenia, HTN, dyslipidemia, PUD, hypothyroid
- No cardiac history
- Chronic diarrhea
- Hypotensive at mid-run and end of HD
- Twice per week HD

Patient Data

- GW 50.5 kg
  - Average wt. gain 3-4 kg which is 6-8% of GW
- Dialysis- L upper arm AVF
  - F160, BPS 300, Dialysate flow 500, dialysate temp 36 C
  - Na 140, K 3.0, Ca 1.25, Mg .3
- Predialysis Bloodwork
  - Hb 96, Na 132, K 4.1, HCO_3 21, albumin 32
- Medications
  - Metoprolol, NTG patch – held prior to HD
  - Glyburide, Pariet, Levothyroxine, Psych meds, EPO, IV iron, Ca, 1-alpha
- Echo – normal LV wall thickness, LVEF 65%

Typical Dialysis

Time	0830	0900	1000	1002	1050	1115	1230
Fluid Removal (L)	0	.67 (1.3%)	1.85 (3.7%)	2.0 (4%)	2.31 (4.5%)	-	3.1 (6.1%)
Blood Volume Changes (%)	0	-	-	-	-	-	-
BP (mm Hg)	159/81	129/68	79/60	106/58	138/66	131/66	140/69
HR (per min.)	56	55	60	56	57	62	65

NS 200 mL
Minimum UF

Write the Dialysis Orders

- Dialysis frequency – increase to 3 times per week
- Dialysis solution
  - Na ramping, maybe 138-132
  - Ca 1.5, Mg 0.75
  - Temp – could decrease lower at time of risk
- Adjust GW, has there been a gain in tissue weight
  - Chronic volume depletion with diarrhea?
- NPO
- Medications - Midodrine 5mg pre-HD
  - Discontinue unnecessary meds that could exacerbate hypotension
  - Increase EPO, ensure adequate iron stores

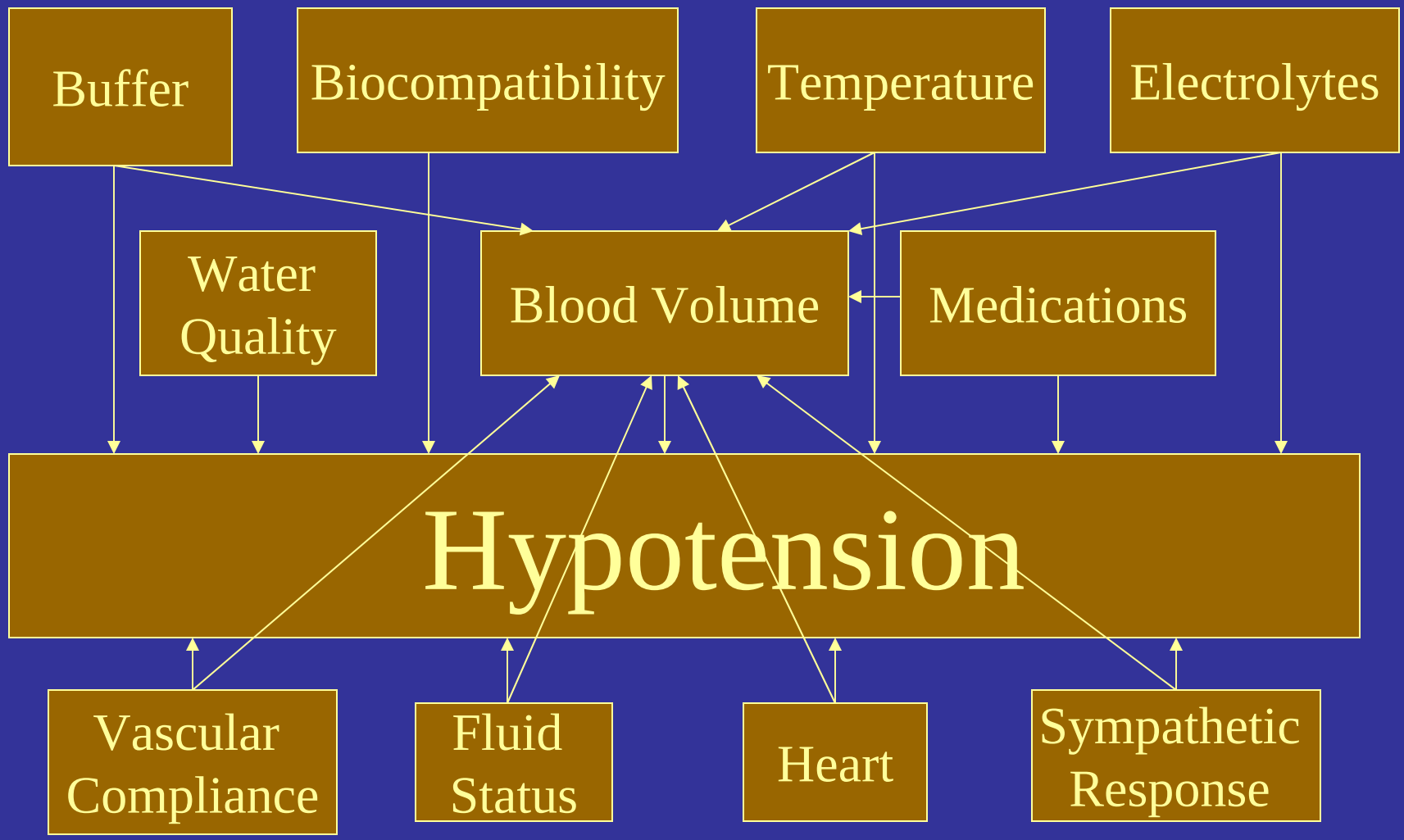
BC Nephrology DAYS 2005

Summary

High Risk Patients

- Elderly
- Established cardiac disease
  - Including LVH
- Diabetic autonomic neuropathy
- Premature vasculopathy
  - Diabetics
  - Hypertensives
  - Smokers
- Excessive interdialytic weight gain
  - >3% of total body weight

Pathways to Hypotension



Contributing Factors in Hemodialysis-Related Hypotension

Dialysis Factors	Dialysate Factors	Patient Factors
Total fluid removal	**Sodium**	**Cardiac function**
Rate of fluid removal	**Temperature**	**Plasma refilling rate**
Rate of solute removal	Calcium	**Autonomic function**
Fall in plasma osmolality	Magnesium	**Initial plasma volume**
Membrane-blood interaction	Glucose	Anemia
Hypoxemia	Potassium	Drug Therapy
Catecholamine depletion	Acetate	Eating
Fluctuating UF rate	pH	Cytokine/NO levels

Simple Steps

- Frequent goal weight assessment
- Encourage patient compliance with sodium and fluid
- Avoid eating on HD
- May avoid antihypertensives on HD days
- Correct anemia
- Supplemental O_2 to improve myocardial performance
- Position patient supine

Manual or Biofeedback Systems

- RBV
  - UF profiling
- Dialysate conductivity
  - Sodium Profiling
- Isothermic dialysis
  - Cool dialysate

Medications

- **Midodrine**
- Sertraline
- Caffeine
- Carnitine?

Dialysate Composition

- Calcium 1.5 or 1.75 bath
- Mg 0.75 bath
- Lower Bicarbonate bath

Thank You

"I was told to keep my presentation interesting.
How do you program a projector to explode?"

Three Priority Actions From Workshop

1.
2.
3.